A COMPARISON BETWEEN GLOBAL AND LOCALIZED RBF MESHLESS METHODS FOR PROBLEMS INVOLVING CONVECTIVE HEAT TRANSFER

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Abstract

Meshless methods are a relative newcomer to the field of computational methods; the term "meshless method" refers to the class of numerical techniques that rely on either global or localized interpolation on non-ordered spatial point distributions. They have the following advantages: (1) domain and boundary discretization is bypassed; (2) domain integration is not required; (3) custom points (e.g. randomly generated or imported from a file) can be used as the domain; (4) exponential convergence for smooth boundary shapes and boundary data can be realized; (5) multi-dimensional problems are naturally handled; (6) implementation is comparatively easy. This paper extends the method developed by Sarler and Vertnik [2006] to solve problems coupled with convective heat transfer. Few studies have been carried out to compare global and localized RBF meshless methods side by side. See, for example, Islam et al. [2012], who demonstrated the advantages of the localized approach for the case of the diffusion-reaction equation in three-dimensions. Here we make a comparison between global and localized radial basis function (RBF) methods after establishing the accuracy of each one based on the solution to benchmark fluid flow problems, including the lid driven cavity, natural convection, and flow over a backward step. Global RBF-based methods have some well-known drawbacks, including poor conditioning of the ensuing algebraic set of equations. While these drawbacks can be addressed, to some extent, by domain decomposition and appropriate pre-conditioning,

our results favor the localized approach.
The attractive feature of the localized RBF method is that it allows field variable derivatives of any order to be estimated by simple inner products of vectors that can be pre-built and stored. Since the multiquadric functions can be evaluated at a setup stage when these vectors are being built, the computational burden of having to evaluate fractional powers and complicated functions at every step of an iteration or time-marching scheme can be avoided. In addition, the memory demands of the localized approach are minimal, as no global collocation matrix needs to be allocated; only small vectors are stored for every one of the data centres. We conclude that localized methods offer tremendous advantages over global RBF-based meshless methods in terms of data preparation, parallelizability, and the possibility for a truly autonomous approach at the problem setup stage.